The Tach-Rotor Adapter Plus (TRA PLUS) works with 3-wire 12VDC fans commonly found in computers, computer power supplies, uninterruptable power supplies, DVRs, servers, and other electrical equipment with active cooling systems. The TRA PLUS is user programmable, converts a tachometer signal, also known as a speed-sensor signal, to a rotor-locked signal, provides fan speed (RPM) indication using an RGB (red-green-blue) LED, and provides alarm detection and indication using an RGB LED and sound via a piezo buzzer.

TACH-ROTOR ADAPTER PLUS

MANUAL 2.5

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INTRODUCTION

The TRA PLUS improves upon the original TRA by adding sound and programmability. The TRA PLUS uses the same microcontroller unit (MCU) used in the original TRA thus leverages previous hardware and software design, development, and testing ensuring a stable, reliable design. The original RPM color schemes and form factor are the same as the TRA and the TRA PLUS fits in the same case. In addition to more DIP switch settings, the user can now program additional parameters to customize the TRA PLUS to their system. The addition of sound enhances visual alerts while providing a convenient feedback mechanism during operation and for quick and easy programming. User programming remains stored even if power is removed and defaults can be restored. The TRA PLUS smartly beeps during power-up (assuming all beeps have not been turned off) indicating whether default or user custom parameters were loaded.

BACKGROUND

DC fans are commonly found in computers, computer power supplies, uninterruptable power supplies, DVRs, servers, and other electrical equipment with active cooling systems. Fans can, however, be noisy due to the speed and volume of air being pulled across its blades. A noise reduction technique is to use a larger fan that spins slower thus producing less noise but without compromising air flow due to its larger size. Of course, there must be room to mount an adapter flange or manifold in addition to the larger fan. Given the explosive growth of the computer industry over the last few decades, fans are available in a wide variety of sizes, speeds, and noise levels. Other features include built-in thermal detection with automatic speed adjustment, manually adjustable speed controls, LEDs, etc.

Computer DC fans started out as simple 2-wire fans for DC voltage and Ground. As computers evolved, 3-wire fans emerged; DC voltage (e.g. +12V), Ground, and a third wire called Sense. The signal on the Sense wire depends on the fan type; Tachometer fan or Rotor-Locked fan. Tachometer fans produce pulses at a rate proportional to fan speed. Rotor-Locked fans produce a static signal that is in one of two states, FAIL (Locked Rotor) or GOOD (Spinning Rotor). Signal waveforms for Tachometer Fans and Rotor-Locked Fans are shown in Figures 1A and 1B respectively.

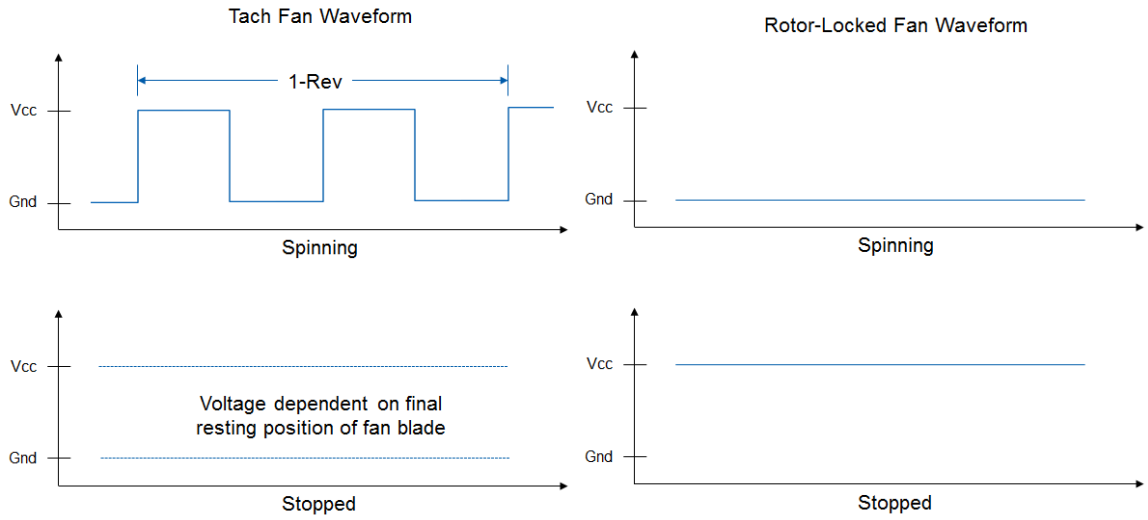

FIGURE-1A: TACH FAN WAVEFORM **FIGURE-1B: ROTOR-LOCKED WAVEFORM**

Fans with tachometer sensors are commonly used in computers as it's a simple matter for the computer's processor to monitor and compute fan speed. For unattended equipment, Rotor-Locked fans are popular as they integrate easily into alarm systems due to their simpler 2-state outputs. Unfortunately, Rotor-Locked fans generally cost more, are not as common as Tachometer fans, and are even harder to find in sizes over 92mm making the noise reduction technique of getting a bigger fan tougher to realize. So the Tachometer-Rotor Adapter (TRA) was born and given the power of the MCU, additional features were added which are described below.

FEATURES

The TRA PLUS provides the following 3 functions:

1. Speed Sensing, Display, and Sound
2. Fault Indication
3. Rotor-Locked Conversion

<u>Speed Sensing, Display, and Sound:</u>

In the same way a computer calculates fan speed; the MCU in the TRA PLUS calculates fan speed and illuminates an RGB (red-green-blue) LED to a color indicating which one of four RPM ranges, or bands, the fan is operating. User fan speed can be verified against the DEFAULT RPM Band Colors and Ranges or the TRA PLUS can be programmed by the user to allow all four colors to span the range of speeds using the fan controller. DEFAULT RPM Ranges can be restored at any time.

Using a combination of filtering and hysteresis, regions between bands were created to suppress LED flicker caused by a fan slowly crossing a band threshold, noise on the voltage/ground signals, or some other disturbance.

The RGB LED can be switched ON or OFF and LED brightness can be set to High or Medium using DIP switches described in the TRA PLUS Features Table.

The TRA PLUS has three sound modes; 1) Normal, 2) Beep Only When Programming, and 3) Disable All Beeps. Each mode is permanently stored once programmed and can be re-programmed up to a million times. The TRA PLUS ships in Normal Sound mode (sound ON for operation and programming).

LED colors are based on the fan's speed and are independent of Output Signal Type selection, e.g. the TRA PLUS will still display color bands representing fan speed even if the TRA PLUS output is set to the 2-state Rotor-Locked waveform.

Fault Indication:

When the fan falls below 30 RPM the LED becomes RED and a 1-second beep occurs every 60 seconds until the fault condition is removed. Sound can be turned ON or OFF using the DIP switches described in Table below. Fan FAIL overrides LED ON/OFF setting.

When the FAIL condition is removed, the TRA PLUS emits 3 short beeps if it has been CUSTOM programmed. If the TRA PLUS is using DEFAULT RPM Band Ranges, the TRA PLUS emits 2 sets of 2 short beeps.

Rotor-Locked Conversion:

The TRA PLUS output can be set to follow the input from the fan's sense wire (known as a tachometer signal - most computers use this type) or can be converted to a 2-state rotor-locked signal where the signal is LOW when the fan is spinning or HIGH (open collector) when the fan is below the FAIL threshold (30 RPM). Fan output selection is made using DIP switches described in the TRA PLUS Features Table.

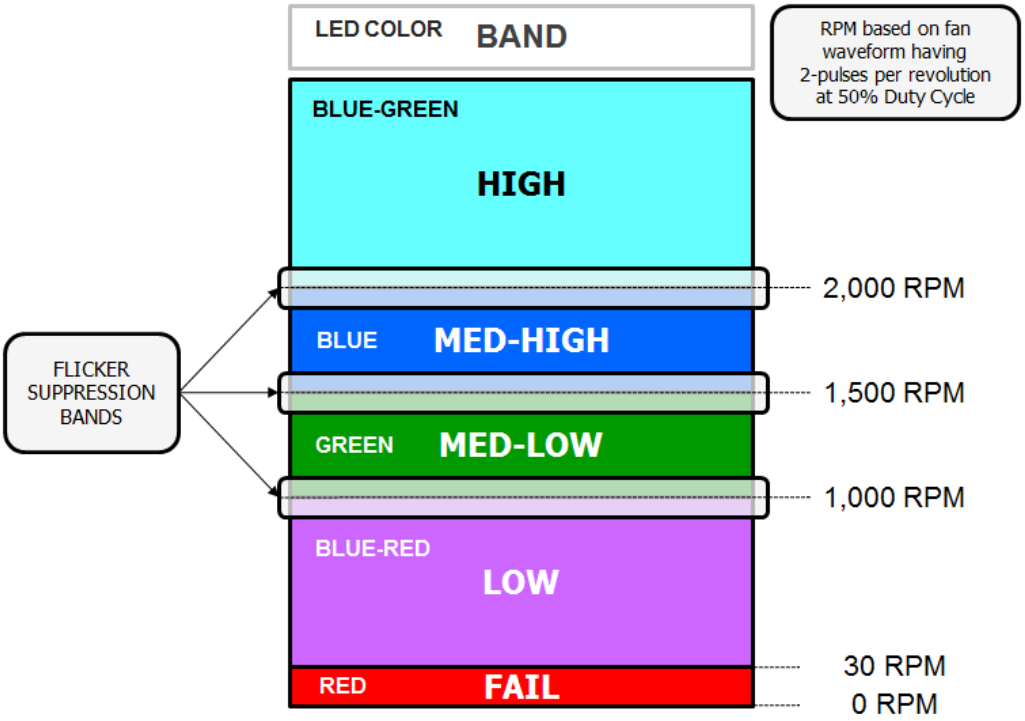

FIGURE-2: DEFAULT LED RPM COLOR BANDS

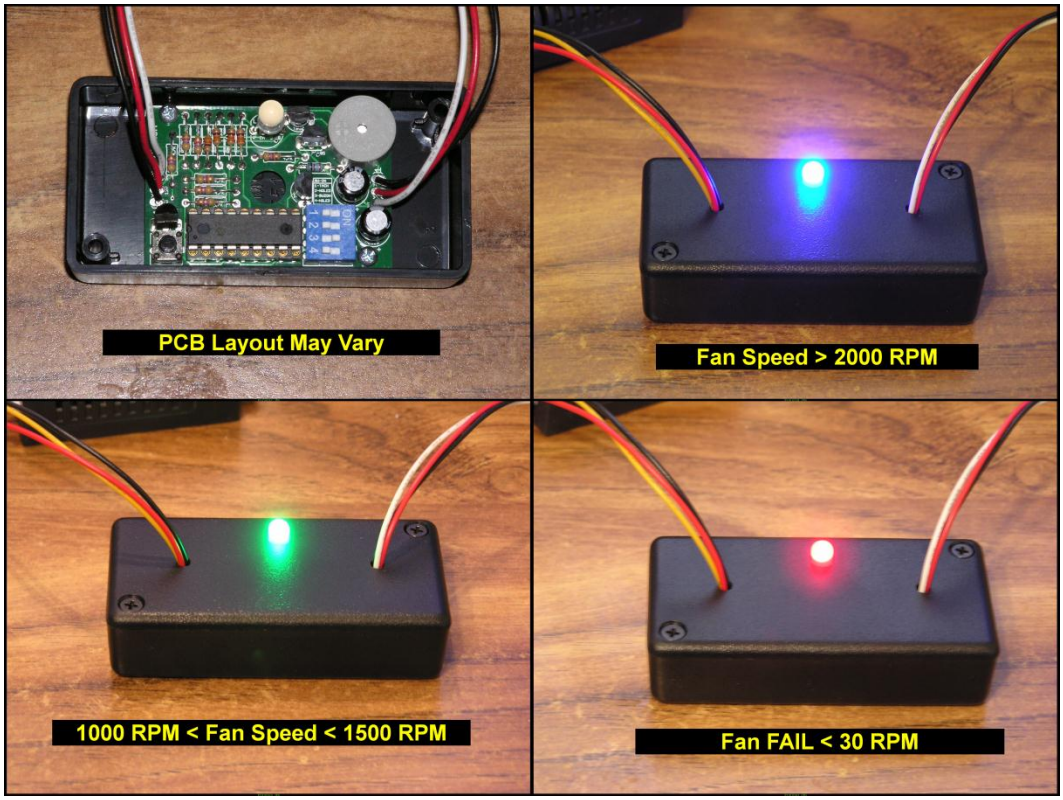

FIGURE-3: ASSEMBLED KIT & OPERATING COLORS

FEATURE	DESCRIPTION	SELECTION METHOD
Output Signal Type	Output sense-wire matches Tachometer Fan input signal or is converted to a Rotor-Locked signal	DIP SW-1 OFF = ROTOR-LOCKED ON = TACHOMETER
LED ON/OFF	Turns the LED ON or OFF	DIP SW-2 OFF = LED ON ON = LED OFF
Fan FAIL	LED turns RED. Fan FAIL overrides LED ON/OFF setting.	FIXED < 30 RPM
	Beeps for 1 second every 60 seconds until the fault condition is removed.	DIP SW-3 OFF = Buzzer OFF ON = Buzzer ON
Fan FAIL Recovery	Beeps when FAIL condition is removed	FIXED
LED Brightness	MEDIUM or HIGH	DIP SW-4 OFF = MEDIUM ON = HIGH
Flicker Suppression	Prevents LED flicker caused by frequency noise, a slowly varying fan, or when the fan slowly crosses a band threshold	FIXED ± 75 RPM
RESET	Resets TRA PLUS (same effect as cycling power)	Momentary Button

RPM Band Ranges	DEFAULT RPM BANDS: HIGH (Blue-Green) > 2000 RPM MED-HIGH (Blue) > 1500 RPM MED-LOW (Green) > 1000 RPM LOW (Blue-Red) > 30 RPM	DEFAULT RANGES & COLORS FIXED
	RPM values at the color boundaries can be modified where all colors are used across the range of speeds created by the fan controller. DEFAULT RPM Band Ranges can be restored at any time.	USER PROGRAMMABLE (DIP SW-1)
Sound	The TRA PLUS has 3 Sound modes: 1. Normal 2. Beep only when programming 3. Disable All Beeps	USER PROGRAMMABLE (DIP SW-3)

TABLE-1: TRA PLUS FEATURES

INSTALLATION

Place the TRA PLUS between the computer's fan and computer's motherboard fan header. For use with a fan controller, connect the fan to the fan controller, connect the fan controller to the TRA PLUS, and connect the TRA PLUS to the computer (or other end-use device).

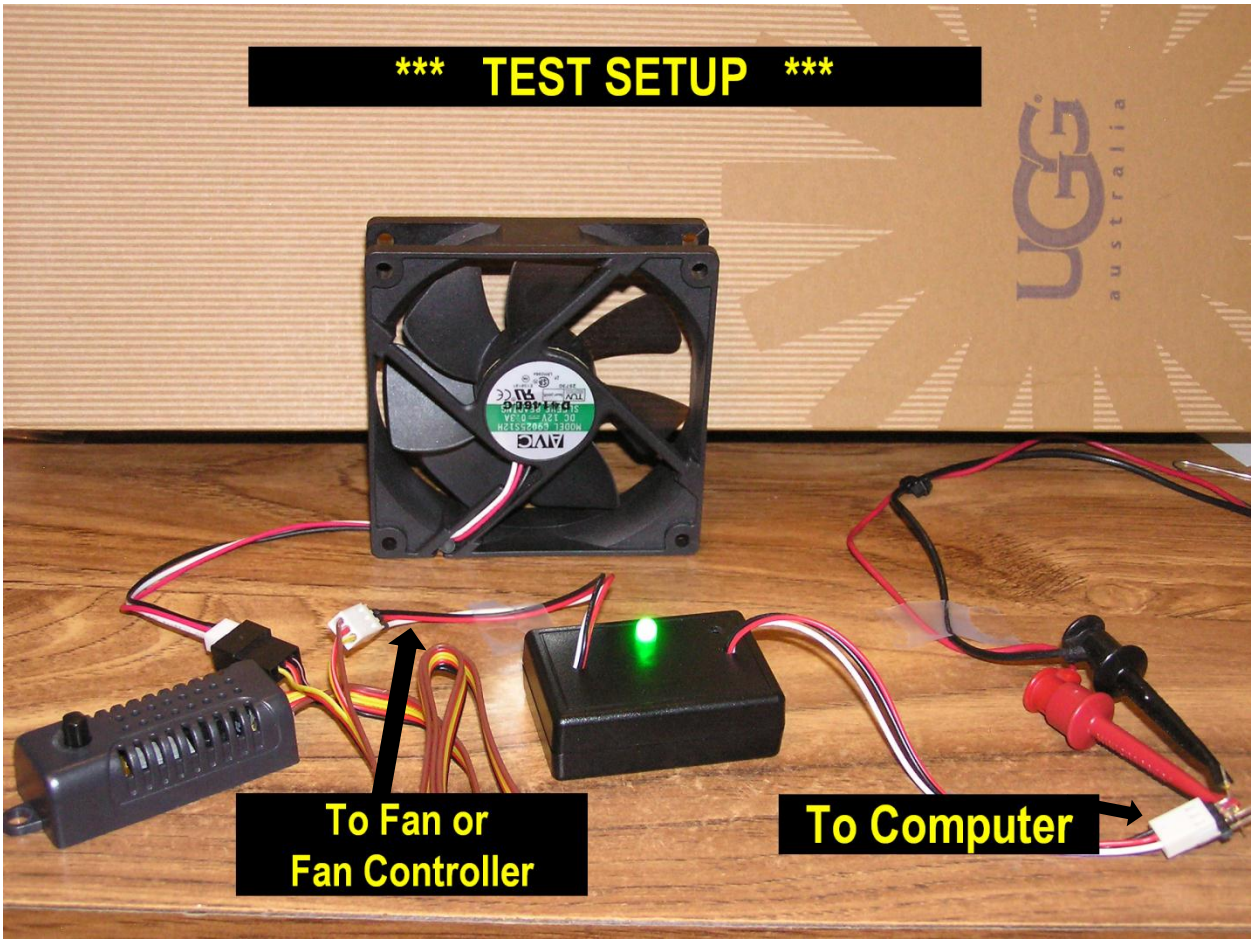

FIGURE-4: TRA PLUS CONFIGURATION USING A FAN CONTROLLER

POWER-ON

At POWER-ON, the TRA PLUS cycles through all 3 colors beginning with Red, then Green, then Blue, and then OFF. Next the TRA PLUS either a) emits 3 short beeps if it has been CUSTOM programmed or b) emits 2 sets of 2 short beeps if the DEFAULT RPM Band Ranges are stored. Once the fan speed is measured, the TRA PLUS changes to the appropriate color.

PROGRAMMING

RPM Color Bands

For systems that have a fan controller that can change fan speed, the TRA PLUS may be able to operate through all 4 DEFAULT RPM COLOR BANDS. However, because fans come in a wide variety of speeds and fan controllers differ, it's possible that not all LED colors will show up with a given system's fan and fan controller combination so the TRA PLUS allows the creation of CUSTOM RPM Band boundaries that utilize all 4 color ranges by allowing the user to simply identify the HIGHEST and LOWEST fan speeds from which the TRA PLUS computes the new ranges. To program the TRA PLUS, please follow the following steps.

1. Place a fan controller between the TRA PLUS and the computer fan as shown in the Test Setup pictures. Set the TRA PLUS DIP SW-1 setting to the OFF position (if it isn't already there).
2. Adjust the fan controller to run the fan at its HIGHEST speed. Change the TRA PLUS DIP SW-1 setting from OFF to ON. The TRA PLUS will beep once indicating the fan's HIGHEST RPM speed was measured.
3. Adjust the fan controller to run the fan at its LOWEST speed. Within 20-seconds (built-in timeout to prevent unintended programming), change the TRA PLUS DIP SW-1 setting from ON back to OFF. The TRA PLUS will beep three times indicating the fan's LOWEST RPM speed was measured, CUSTOM RPM Band Ranges for all 4 bands were computed, and the new CUSTOM band ranges were permanently stored in non-volatile memory ensuring the TRA PLUS retains its values if power is removed or cycled.

After programming, DIP SW-1 may be returned to the ON position if TACHOMETER operation is desired (output is the same as the input). Be sure not to move DIP SW-1 from ON back to OFF for 20-seconds or additional unwanted programming may occur. To eliminate the 20-second waiting requirement, simply reset the TRA PLUS using the momentary switch.

To restore DEFAULT RPM bands, follow the above steps but instead start by entering in the LOWEST RPM first then finish by entering in the HIGHEST RPM next. The TRA PLUS emits 2 closely spaced sets of 2 short beeps when programming is complete indicating DEFAULTS have been restored.

SOUND

The TRA PLUS has 3 sound modes.

Beep Normally:

1. Set DIP SW-3 to ON. Moving from OFF to ON will cause the TRA PLUS to beep once.

Beep Only When Programming:

1. Set DIP SW-3 to OFF. No beeps will occur during operation.

Disable All Beeps:

1. Set the TRA PLUS DIP SW-3 setting to the OFF position.
2. Change the TRA PLUS DIP SW-3 setting from OFF to ON. The TRA PLUS will beep once.
3. Within 5-seconds change the TRA PLUS DIP SW-3 setting from ON back to OFF. The TRA PLUS will beep twice indicating TRA PLUS beeps have all been disabled.

Enable All Beeps (from a Disabled Configuration):

1. Set the TRA PLUS DIP SW-3 setting to the OFF position.
2. Change the TRA PLUS DIP SW-3 setting from OFF to ON. The TRA PLUS will beep twice.
3. Within 5-seconds change the TRA PLUS DIP SW-3 setting from ON back to OFF. The TRA PLUS will beep twice indicating the TRA PLUS beeps have all been re-enabled.

BUZZER LOUDNESS

To obtain louder sounds, the buzzer can be mounted on top of the case instead of inside. Ensure when placing the buzzer there is adequate clearance beneath it for the buzzer pins. The example in the picture shows the buzzer mounted just above the buzzer location on the PCB. To mount, drill two small holes on the top of the case for the buzzer pins to poke through and solder wires from the buzzer pins down to the PCB buzzer pads (the square pad is positive). Double sided sticky tape can be used to hold the buzzer to the case.

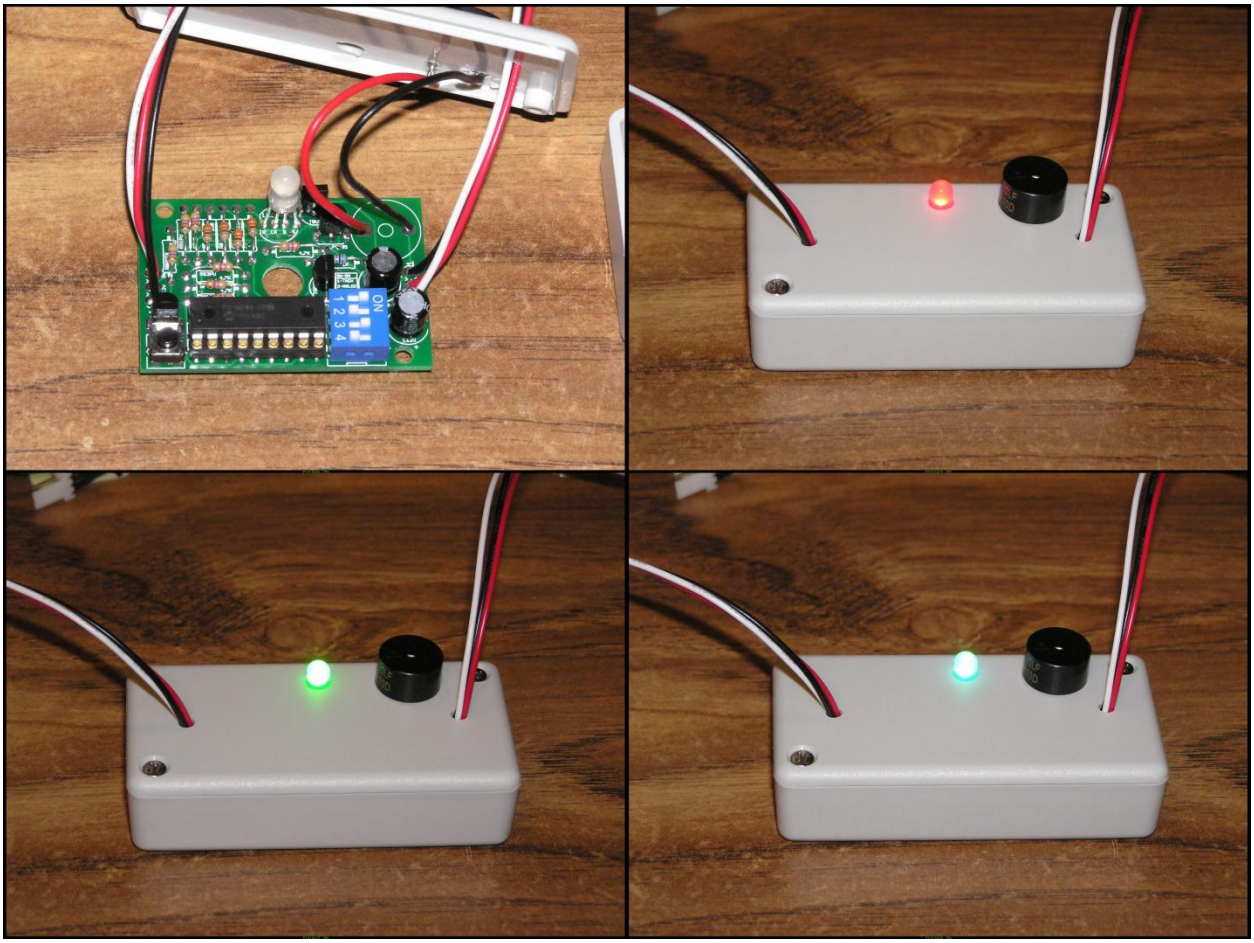

FIGURE-5: BUZZER MOUNTED ON TOP OF THE CASE

For the hobbyist and sound enthusiast, sound can be increased with a larger piezo buzzer and more drive current. Piezo buzzer must operate with 12VDC. Typical Kit piezo is 14mm diameter, draws < 10mA to deliver 86dBA of sound pressure. The piezo drive transistor, TBUZ, is a 2N4401 inside a TO-92 package which drives up to 600mA. For even greater current drive (e.g. > 1 amp), room exists to replace the TO-92 with a TO-226 package Darlington Pair transistor (ensure compatible pinout for replacement transistor – see layout) for sirens or sounders.

KIT OVERVIEW

The TRA PLUS Kit comes with a custom PCB board, components, and a case. A DIP switch allows user configurability. The PCB layout uses only through-hole mounting allowing for simple-level soldering skills and quick assembly. The PIC16F88 microcontroller sits inside a solder mounted DIP socket allowing the PIC to be easily removed and inserted for firmware updates.

Required Tools or Supplies:

- PIC16F88 Programmer
- Soldering equipment (Iron, Solder, Flux)
- Wire cutting and stripping tool
- Drill, 1/8" drill bit, 13/64" drill bit
- Small screwdriver (slotted or Philips to fit case screws)
- Needle nose pliers

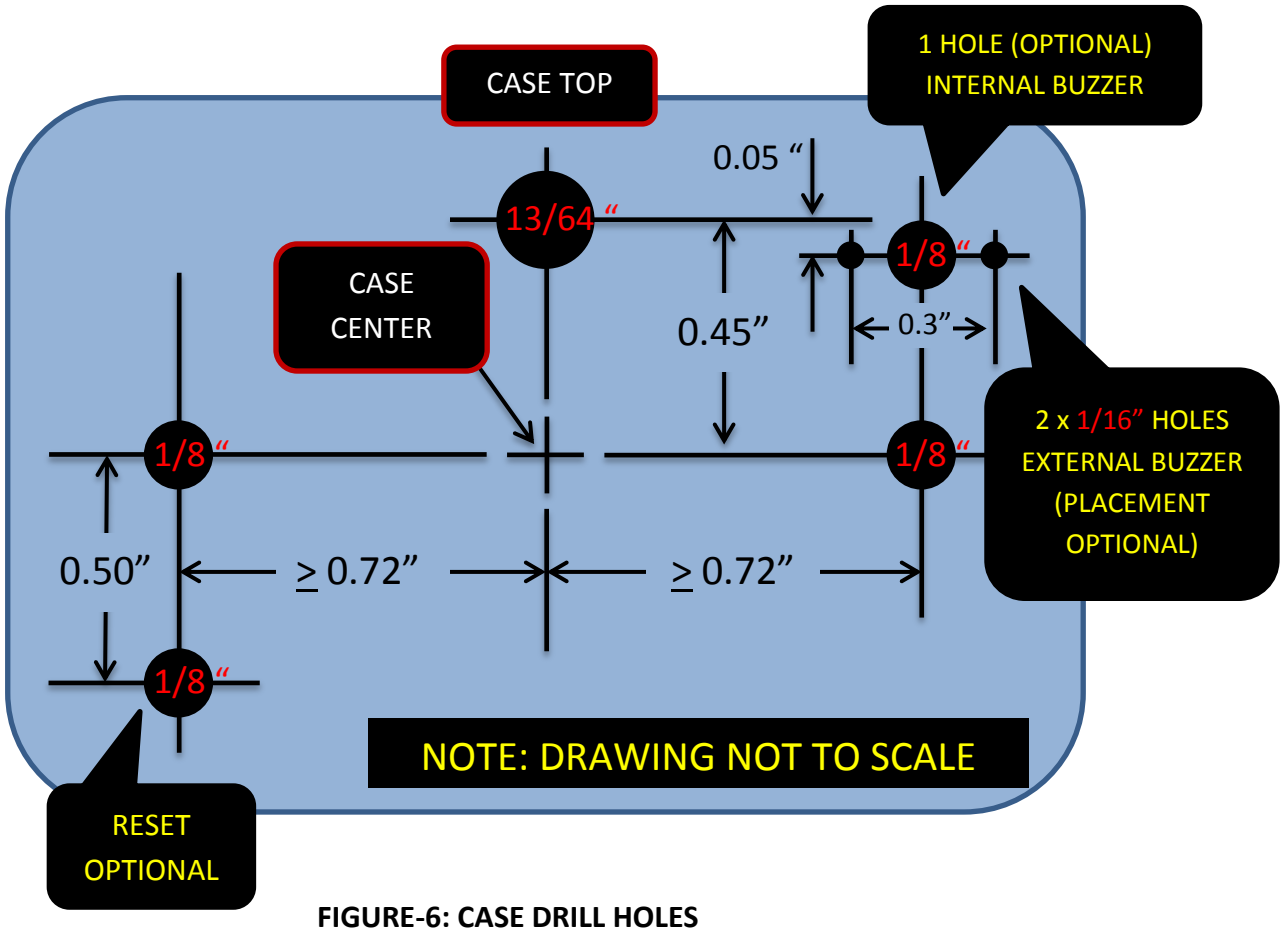

FIGURE-6: CASE DRILL HOLES

Part	Jameco PN	Description and Link	Design Qty	Kit Qty
1	51182	IC,78L05,+5V,TO-92	1	1
2	312733	IC,MCU,PIC16F88-I/P,8-BIT	1	1
3	112231	SOCKET,IC,18PIN,DUAL WIPE	1	5
4	109059	SWITCH,DIP,SPST,4 POS,8-PIN	1	1
5	94432	CAP,RADIAL,MINI,7MM,100uF16V	2	2
6	783498	NPN/40V/0.6A/100-360/TO-92	3	5
7	2095120	SWITCH,PB,TACT,SPST,OFF-(ON)	1	1
8	2128500	LED,RGB,WATER CLEAR,T1-3/4,2.0	1	1
9	2138222	CASE,PLASTIC,3.2" x 1.6"x 0.8"	1	1
10	2157159	RES,CF,1K OHM,1/4 WATT,5%	1	10
11	2158864	RES,CF,4.7K OHM,1/4 WATT,5%	7	10
12	690742	RES,CF,330 OHM,1/4 WATT,5%	4	10
13	196357	PIEZO BUZZER/13.8MM/12V	1	1
14	101470	10" BAT CONN (WIRES FOR EXT BUZ)	1	1
15	Custom	PCB	1	1

TABLE-2: TRA PLUS CIRCUIT DESIGN QTY / TRA PLUS-KIT QTY [1, 2]

Notes:

1. Representative Kit at time of printing. Parts subject to change and availability.
2. Similar parts may be substituted. Please refer to schematic for design considerations and/or limitations.

KIT ASSEMBLY STEPS

1. Prepare Case and Fan Cables
    a. Cut the fan extension cable into 2 equal halves
    b. Drill holes in case as shown in the Case Drill Holes figure
        i. RESET and BUZZER holes are optional
        ii. Size the RESET hole for intended RESET device, e.g. 1/8” (small) for toothpick, 13/64” (medium) for small screwdriver, etc.
    c. Drill 1 (one) hole for Piezo Buzzer (optional) if internal mounting OR drill 2 (two) holes to accommodate the Piezo Buzzer pins for external mounting
2. Install Components
    a. Solder 12 (twelve) resistors
    b. Solder 1 (one) 18-pin IC carrier
    c. Solder 1 (one) DIP Switch and 1 (one) Tactile Momentary Switch
    d. Solder 1 (one) Piezo Buzzer to PCB (if internal mounting)
    e. Solder 2 (two) capacitors
    f. Solder 3 (three) transistors
    g. Solder 1 (one) 5V regulator
    h. Solder 1 (one) 2-pin header
    i. Solder 1 (one) RGB LED to the PCB (note: mount RGB LED high enough so the LED pokes through the 13/64” hole on case top)
    j. Insert PIC into the 18-pin IC Carrier
    k. Set DIP switch to desired settings
3. Install cables
    a. Feed cables through 1/8” holes in top cover
        i. Cable with MALE connector goes through LEFT hole
        ii. Cable with FEMALE connector goes through RIGHT hole
    b. Strip ~ 0.5” insulation from the 3 wires on each cable
    c. Solder cable with MALE connector to FAN-IN pads (see label on PCB)
    d. Solder cable with FEMALE connector to FAN-OUT pads
    e. Affix the Piezo Buzzer to top of the case, e.g. with double-sided sticky tape, then solder wires from PCB to Piezo Buzzer (if external mounting)
4. Assemble
    a. Gently pull/push on the wires to bring the PCB up to the case top
    b. Gently align the RGB LED to poke through the case top 13/64” hole
    c. Fasten the case halves together using the case screws
5. Program as desired

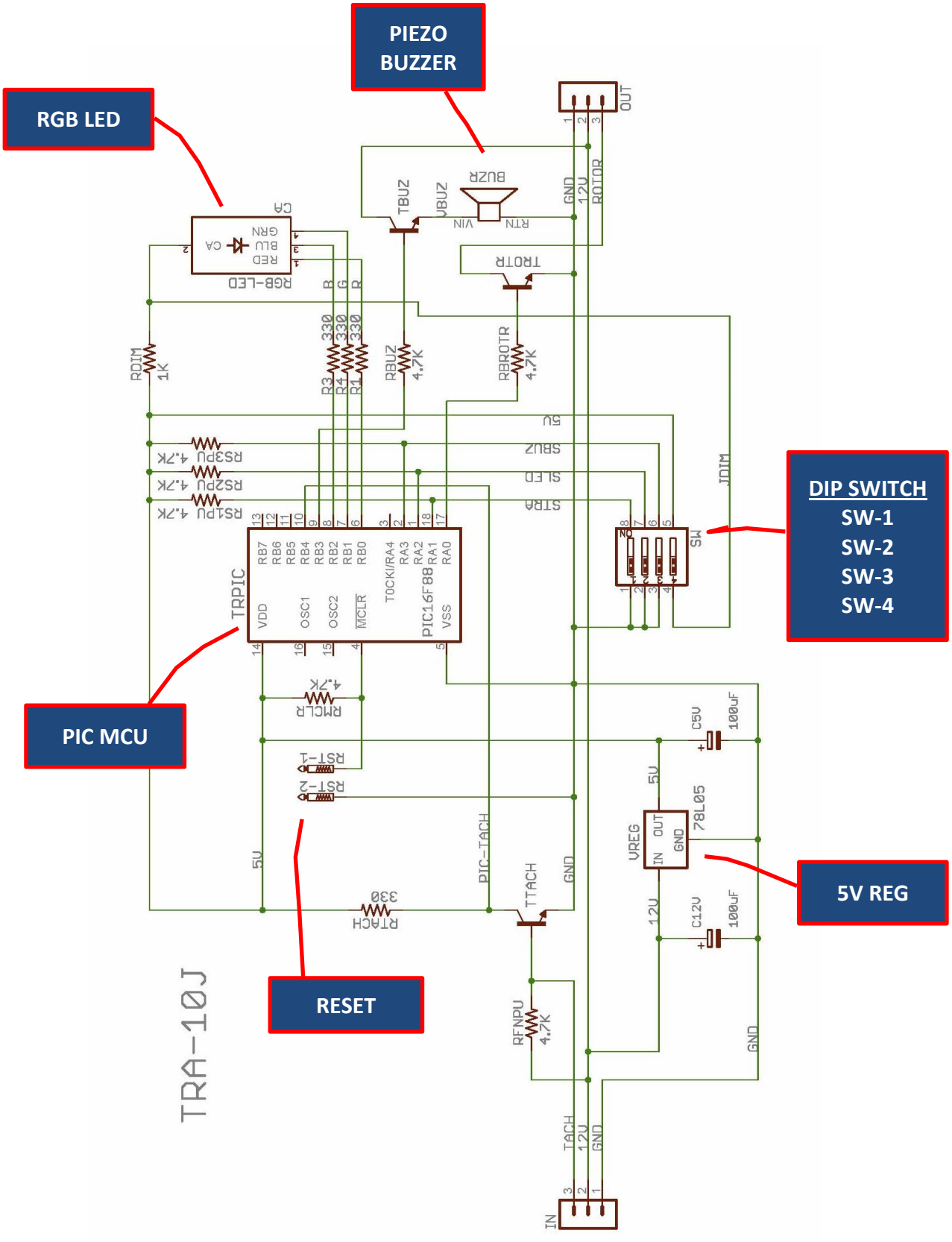

FIGURE-7: TRA PLUS SCHEMATIC AND KEY COMPONENTS

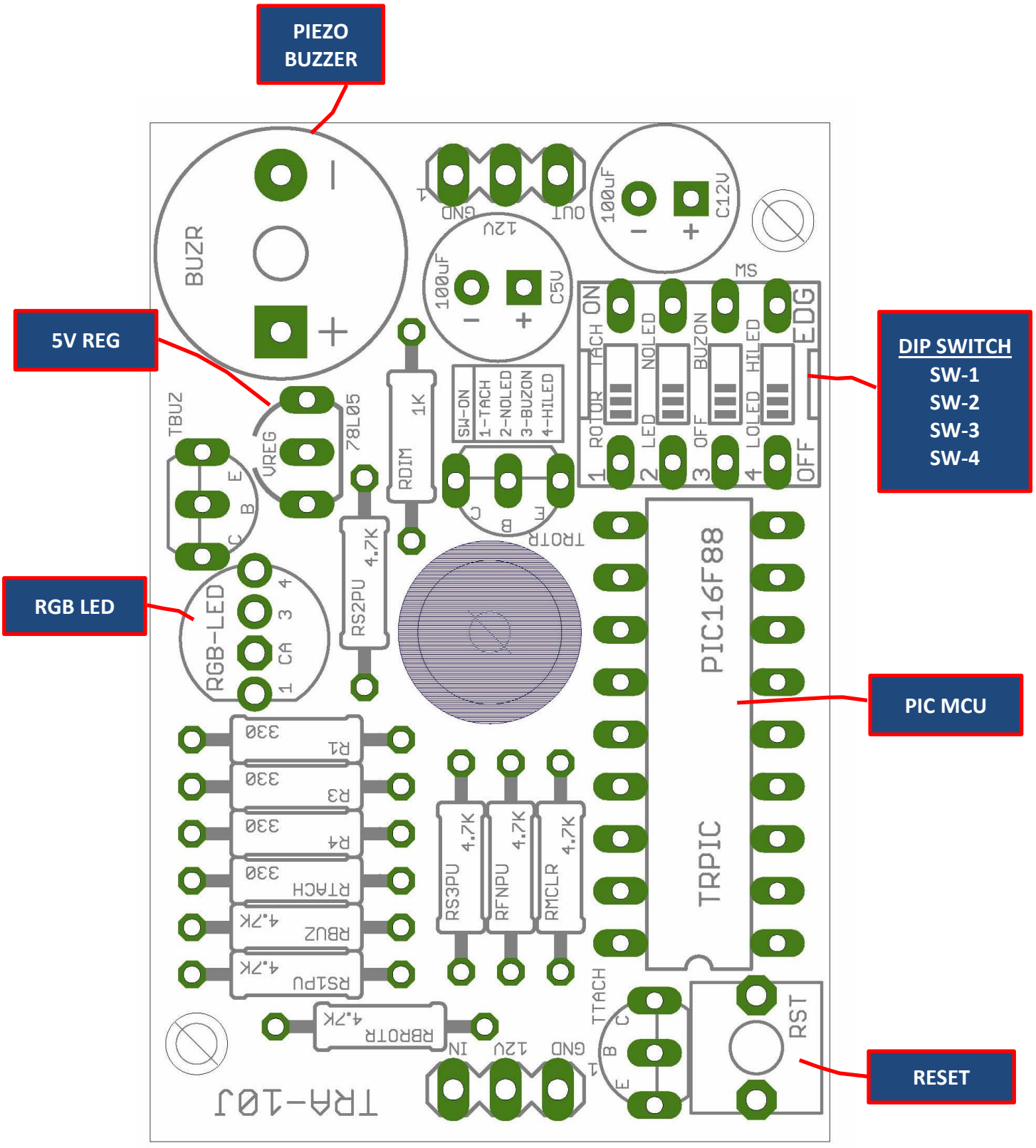

FIGURE-8: TRA PLUS PCB LAYOUT AND KEY COMPONENTS

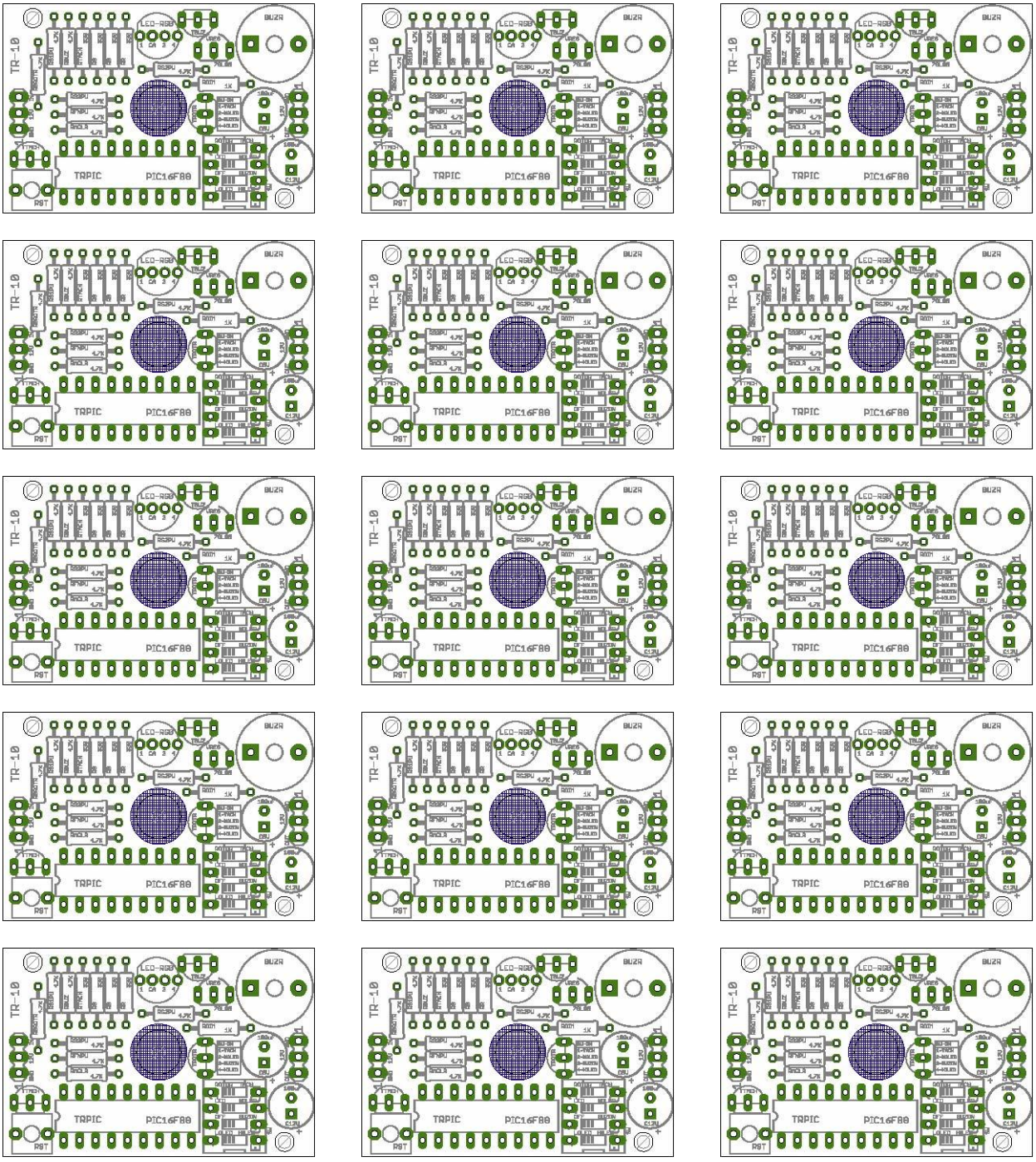

FIGURE-9: TRA PLUS LAYOUT TEMPLATES

(HELPFUL FOR DRILLING HOLES – PRINTS 1:1 SCALE ON MOST PRINTERS)